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(71) Applicant
Richard Scheuchl,
Brombeerweg 2, D-8038 Grobenzell b, Munchen, Federal Republic of Germany

(72) Inventor
Richard Scheuchl

(74) Agent and/or Address for Service
Pollak Mercer & Tench, High Holborn House, 52/54 High Holborn, London WC1V 6RY

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(54) Solvent recovery from process gas streams

(57) A plant and a method for recovery of solvents, for example hydrocarbons or halo-hydrocarbons, from a process gas stream includes one or more adsorbing units (9,13), each comprising a preferably rotatable adsorbing disc (50) divided into sectors. One disc sector (51) is included in the adsorbing circuit (22-24; 14,15) and another sector (52) is included in a regeneration circuit (1,2; 5, 6, 10, 11).

Fig. 1

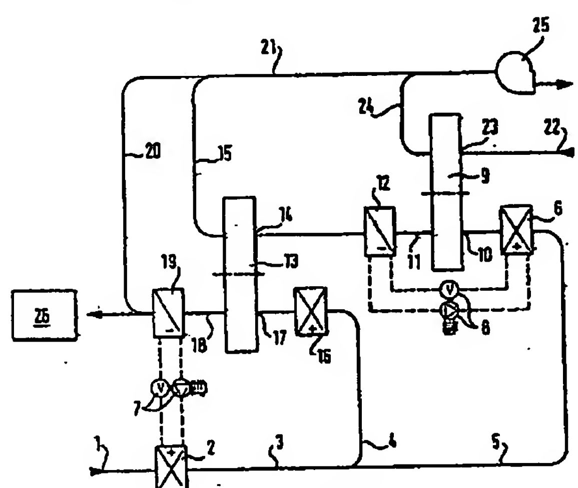

Fig. 3

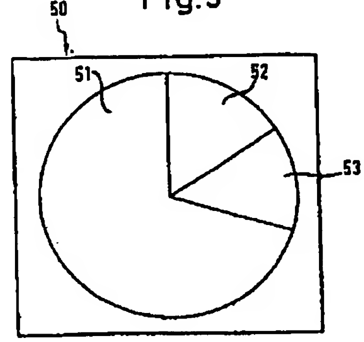

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Fig.1

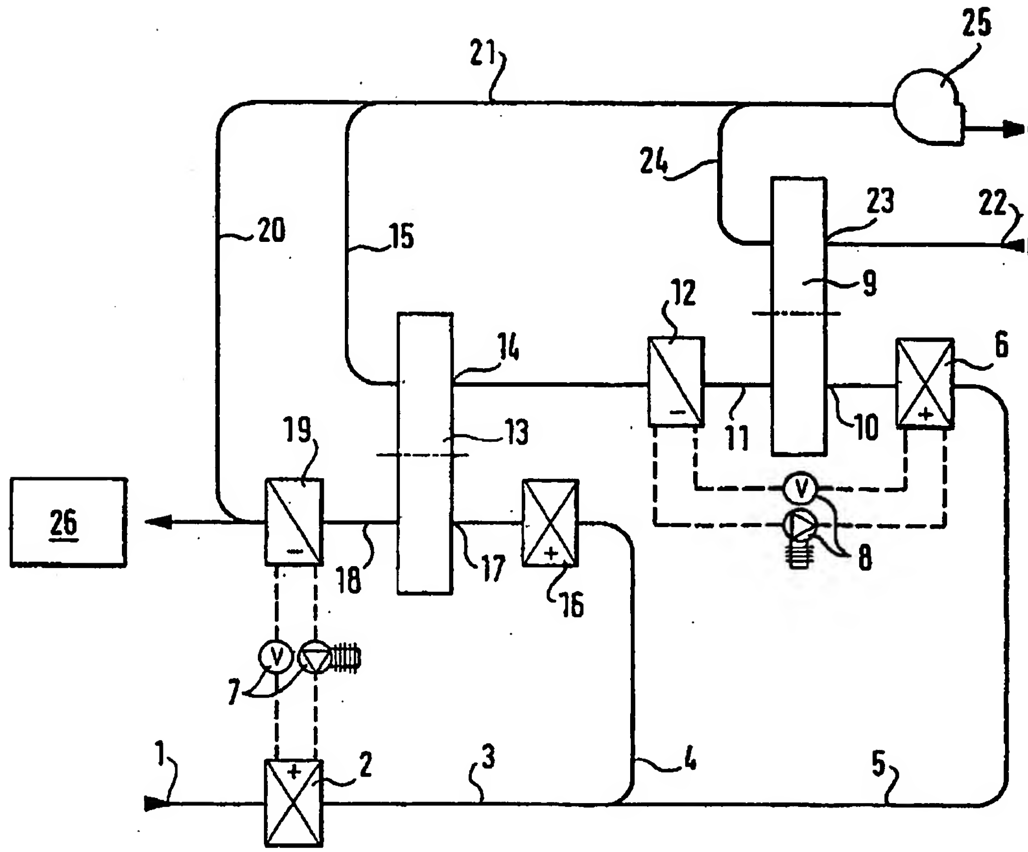

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Fig. 2

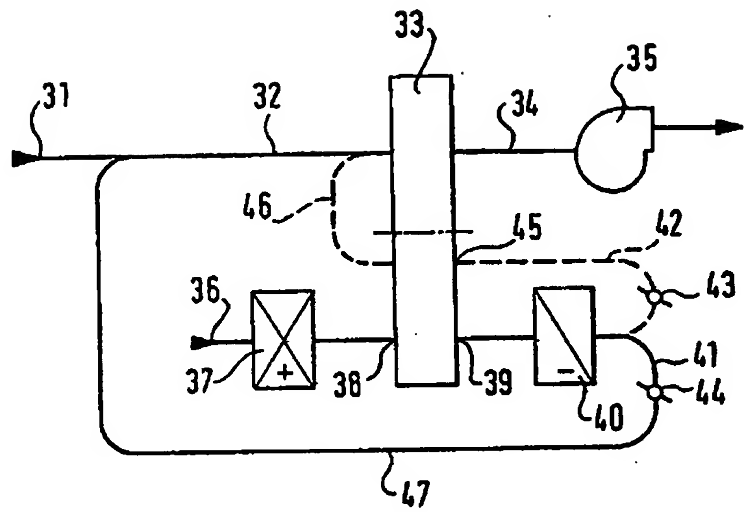
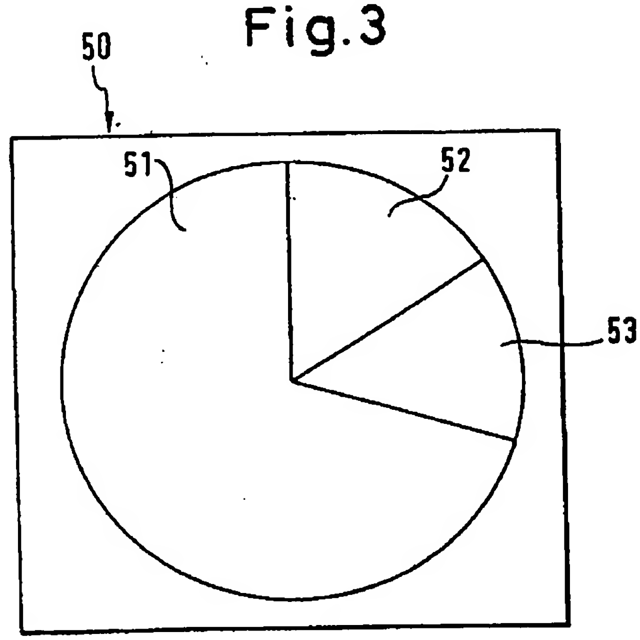


Fig. 3



SPECIFICATION

Solvent recovery from process gas streams

This invention relates to a plant for the recovery of solvents, for example hydrocarbons or halo-hydrocarbons, from process gas streams. Such a plant includes at least one adsorber unit, through which the solvent-containing process gas stream is passed, and a regeneration circuit for regenerating the at least one adsorber unit, in which a regeneration gas, preferably heated, flows and which also comprises a heater and cooling means for the regeneration gas.

Plants for the recovery of solvents from process gas streams are known, having widely differing forms of construction. Most plants of this kind use adsorber units in the form of relatively large containers, which are filled with an adsorbent material. Depending upon the capacity of such a plant, the weight of the adsorbent material in such a container can amount to 1 tonne or more.

From DE-OS 3303423, for example, a method is known for regenerating the adsorber units of a plant for the low-water recovery of solvents from a gas stream, according to which the desorbate expelled from an adsorber unit is first transferred to a regeneration adsorber unit by means of an inert gas stream. The inert gas leaving the regeneration adsorber unit is again heated and is used in the circuit for regenerating one of the operative adsorber units. By using an additional adsorber unit, it is possible to produce a comparatively very pure inert gas stream, for regenerating the operative adsorber units, so that with this known method a very high efficiency can be attained in desorption of the adsorber units.

However, a plant for carrying out this known method is very costly, because complicated and expensive equipment must be used, for example, in order to detect the degree of saturation and the time of saturation of an operative adsorbing unit. Furthermore, with such a plant, very heavy duty precision valves must be used, in order to meet the rigorous prescribed conditions.

The purpose underlying the invention is to provide a plant for the recovery of solvents from a process gas stream of the above-mentioned kind, which can be made much more simply and can therefore be assembled at a much reduced cost and can be manufactured cost-effectively using the modular principle of construction.

According to one aspect of this invention, therefore, a plant for the recovery of solvents of the type described initially is provided, wherein the at least one adsorbing unit comprises an adsorbing disc divided into a plurality of sectors, one sector being included in the adsorbing circuit and at least a second sector being included in the regeneration circuit.

The invention also resides in a method of solvent recovery, using a plant according to the invention, in which at least a part of the regenerated and cooled regeneration gas is branched off from the regeneration circuit and is passed through a cooling sector of the adsorbing disc.

The invention also consists in recovered solvent, obtained in a plant or by a method of the invention.

A solvent recovery plant having the features of the present invention results in the following advantages, compared with known plants of such general kind:

The plant can be operated in a highly energy-saving way because energy-saving equipment, for example heat pumps, can be used very effectively.

Furthermore, the plant needs much fewer conduits and also extremely simple regulating or control equipment and it can be delivered to an owner in a condition ready for use, since it can be made with a much reduced constructional size. The cost of installation is also relatively low and furthermore complete removal can be carried out easily, for example by connecting the plant to a downstream burner unit.

By using an adsorber disc, instead of the known bulky and large containers, continuous regeneration of the adsorbent medium can be carried out, since the adsorber disc can undergo a continuous rotary movement, so that saturated portions of the adsorber unit continuously move into the regeneration circuit and are regenerated there.

A particularly advantageous feature of the invention involves the provision of a cooling sector on the adsorber disc, which preferably adjoins the sector (in the rotational direction) in which the regeneration is carried out, so that, after regeneration of a sector-shaped portion of the adsorber disc, this portion is cooled and can therefore be used again for further operation or adsorption.

A further particular advantage of the rotatable adsorber disc is that a plant can be modified to have different adsorption capacities, by rotating the adsorber disc at different rotational speeds, so that a plant can be modified over a maximum range of capacity to have a desired operative capacity, where the regulating or control equipment can be made extremely simply in comparison with known plants.

Furthermore, the invention can also be carried out advantageously in that the at least one adsorber disc contains activated carbon as the adsorbent material. In a practical construction of the adsorber disc, preferably this is divided into a plurality of equal sectors, for example by means of radially-extending partitions, and activated carbon mats are inserted in the individual sectors and, after a predetermined period of operation of the plant, can be renewed at any time without difficulty.

In order to increase still further stripping of the solvents from process gas streams, it is also possible to connect several adsorber units or discs in series.

In one preferred embodiment, a second adsorber unit is provided, having an adsorption sector, included in the regeneration circuit of a first adsorbing unit and a regeneration sector included in a further regeneration circuit. By this kind of series connection of two adsorber units, the regeneration gas loaded with solvent can be regenerated, i.e. freed from solvent, in the second adsorber unit. With this embodiment, the second adsorber unit only serves for removing solvent from the regeneration gas, so that it can be used again or introduced into the purified process gas stream.

In accordance with a second embodiment of the invention, at least a portion of the regenerated and cooled regeneration gas is branched off and passed through a cooling sector of the adsorber disc, in order

to bring the adsorption medium, after its regeneration, again to a desired temperature.

Further advantageous embodiments and features according to the invention are indicated below. In order that the invention may be fully understood and appreciated, preferred embodiments are described below in conjunction with the accompanying drawings, in which:

Figure 1 shows a block diagram of a plant for the recovery of solvents from a process gas stream according to one embodiment of the invention;

Figure 2 shows a second embodiment of a plant for the recovery of solvents from a process gas stream, in which only a single adsorber unit is used; and

Figure 3 shows a diagrammatic representation of an adsorber disc according to the invention.

Figure 1 shows a first embodiment of a plant for the recovery of solvents, which comprises two series-connected adsorber units 9 and 13. Each adsorber unit in the plant of Figure 1 comprises an adsorber disc, shown diagrammatically in Figure 3.

With this kind of embodiment, the adsorber disc is divided into three sectors, namely a main sector 51, a regeneration sector 52 and a cooling sector 53. In this embodiment the main or adsorption sector 51 is much larger than the regeneration sector 51 and the cooling sector 52.

The solvent-containing process gas stream is passed through the adsorption sector 51, the regeneration gas flows through the sector 52, whereas a cooling medium or a cooled gas flows through the cooling sector 53.

The adsorber disc 50 is rotatable about a central axis (not shown) and, during operation of the plant, undergoes a uniform rotary movement, so that portions of the adsorption sector 51 continuously enter the regeneration sector 52 and are regenerated within this sector. The adsorbent material of the adsorber disc can thus be continuously regenerated and the regenerated portions of the adsorber disc are then cooled to a desired temperature in the cooling sector 53, so that, after leaving the cooling sector 53, they are again ready for further adsorption. The adsorber disc 50 comprises activated carbon.

Although not shown in Figure 3, the adsorber disc 50 can be divided into sectors of equal size by means of radially-extending partitions, activated carbon mats forming the adsorption medium being inserted in the sector-shaped spaces. The latter feature of construction is especially advantageous, in that the adsorption medium in some of the sectors can be exchanged without any problem or can also be exchanged in all the sectors, without the adsorber disc itself having to be renewed.

In the plant shown in Figure 1, the adsorber units 9 and 13 therefore each comprise the adsorber disc 50 shown in Figure 3.

In Figure 1, a solvent-loaded process gas is introduced at 22 into the plant and, at 23, passes to the first adsorber disc or the adsorption section 51 of the adsorber disc. After passing through the adsorption medium of the adsorber disc 50, the process gas is less enriched and is discharged from the plant through a line 24 and a blower 25 as cleaned process gas.

At 1, a regeneration gas is introduced into the plant and flows via a heater 2 to a heat pump 7 in a conduit system 3, 4 and 5. A portion of the preheated regeneration gas passes via the line 5 to a heater 6 and then, at 10, enters the regeneration sector 52 (see Figure 3) of the adsorber disc 15, then leaves the regeneration sector 52 via the line 11 and is introduced into a cooler 12, which can also be part of a heat pump 8. After cooling, the regeneration gas enriched with the solvent is introduced at 14 into the adsorption sector 51 of a second adsorber disc 50 (see Figure 3), wherein it is stripped and can therefore be used again as a cleaned regeneration gas or, according to the embodiment of Figure 1, it can pass via the line 15 to a collecting conduit 21 along which the purified process gas also flows.

A second part of the preheated regeneration gas flows via the line 4 through a further heater 16 and then, at 17, enters the regeneration sector 52 of the adsorber disc 50 in a heated condition, so that the adsorber disc can be continuously regenerated, because it is rotating. The regeneration gas enriched with solvent leaving the regeneration sector flows via a line 18 to a cooler 19, in which it releases the solvent which is then collected in a solvent-collecting tank 26. The stripped regeneration gas can either be used as new regeneration gas or can be passed via a line 20 to the collecting conduit 21, in which the cleaned process gas is also flowing.

The plant shown in Figure 1 has significant advantages over known plants, because the entire cost of control and regulation can be kept very low, i.e. only the rotational speed of the adsorber disc 50 need be adjusted to the desired capacity, which can be effected by means of simply-constructed regulating or control equipment.

It will be clear to a person skilled in the art that further heat pumps can also be used, for example between the cooler 19 and the heater 16.

Furthermore, it is also possible to increase the number of the downstream adsorber units or discs, so that the number of adsorber discs used in a plant is greater than 2.

In the embodiment according to Figure 1, both the process gas and the regeneration gas are drawn through the plant by means of the blower 25. However, it is also possible to force both the process gas and also the regeneration gas through the plant. The process gas can comprise process air, while the regeneration gas can also comprise regeneration air or an inert gas.

According to the second embodiment shown in Figure 2, in contrast to the embodiment according to Figure 1, only a single adsorber unit 33 in the form of an adsorber disc 50 (see Figure 3) is used. With the plant according to Figure 2, the solvent-loaded process gas enters the plant at 31 and then flows through a line 32 to an adsorber sector 51 of the adsorber disc 50. It then flows as a purified process gas via a line 34 and a blower 35 to be discharged from the plant.

At 36, regeneration gas is introduced into the plant and is heated by means of a heater 37 to the desired regeneration temperature. At 38, the heated regeneration gas enters the regeneration sector 52 (see Figure 3) of the adsorber disc 50 and leaves the regeneration

sector at 39 to be cooled in a cooler 40, so that the regeneration gas is stripped of solvent, which is collected in a solvent-collecting tank, (not shown). In the purified and cooled condition, the regeneration gas then passes into a conduit system 41, 42, in order to be mixed on the one hand, via a line 47, with the solvent-loaded process gas or to be passed at least partly via a line 42 (shown dotted) to the cooling sector 63 of the adsorber disc 50, so that the regenerated sections of the adsorber disc are thus cooled. The regeneration gas can then either be fed into the plant via a line 46 (shown dotted) as clean regeneration gas or can be mixed with the solvent-loaded process gas according to the embodiment shown.

Also, with the plant according to Figure 2, both the solvent-containing process gas and also the regeneration gas can be drawn through the plant. It is also possible to force the process gas and also the regeneration gas through the plant.

43 and 44 designate valves for adjusting the proportion of cooling gas and regeneration gas which are mixed with the process gas.

Also, in the plant according to Figure 2, the operative capacity can be controlled and adjusted simply, by suitably adjusting the rotational speed of the adsorber disc 50 or by controlling the rotational speed in dependence upon the respective throughput quantity.

It will be clear to a person skilled in the art that both the plant according to Figure 1 and the plant according to Figure 2 can be changed without exceeding the scope of the present invention. It is possible, for example, with the plant according to Figure 2, to use one or several heat pumps in order to achieve an energy-saving operation.

Furthermore, it is also clear that both the plant according to Figure 1 and the plant according to Figure 2 can be constructed in a very compact way either horizontally or vertically (with reference to the adsorber discs) so that both forms of apparatus can also be constructed or also enlarged according to the modular unit principle.

Furthermore, the whole plant can be operated in a highly energy-saving manner and renewal of the adsorption material can also be carried out very simply, if each adsorber disc comprises individual sectors which are filled with activated carbon mats, as already mentioned.

Furthermore, it is also possible to use another form of construction, instead of the one discussed above. For example, instead of individual sectors of the adsorbing discs, exchangeable filter cartridges are used, where at least one filter cartridge is always located in the regeneration circuit. Such a construction is described in DE-OS 3100788, for instance.

In addition, it is also possible to introduce the regeneration gas either in the flow direction of the process gas or in the counter-flow direction through the respective adsorber disc.

A special advantage of the plant according to Figure 1 and also according to Figure 2 is that switching between different adsorber units need not be carried out in order to connect the one or other adsorber unit into the regeneration circuit, but that continuous regeneration can be effected in each adsorber unit and so a group of conduits and valve devices and monitoring means for monitoring the degree of saturation of the adsorption material etc. can be saved.

All technical features mentioned in the specification and shown in the drawings are important features of the invention.

CLAIMS

1. A plant for the recovery of solvents, for example, hydrocarbons or halo-hydrocarbons, from a process gas stream, including at least one adsorbing unit through which the solvent-containing process gas stream is passed and a regeneration circuit for regenerating the at least one adsorbing unit, in which a preferably heated regeneration gas flows and which comprises a heater and cooling means for the regeneration gas, wherein the at least one adsorbing unit comprises an adsorbing disc divided into a plurality of sectors, one sector being included in the adsorbing circuit and at least a second sector being included in the regeneration circuit.

2. A plant according to claim 1, wherein at least a third sector is adjacent the second sector and is included in a cooling circuit.

3. A plant according to claim 1 or 2, wherein the adsorbing disc contains activated carbon as an adsorbent material.

4. A plant according to any preceding claim, wherein the adsorbing disc is divided into equal sectors by means of radially-extending partitions.

5. A plant according to claim 4, wherein each sector is filled with sector-shaped activated carbon mats.

6. A plant according to any preceding claim, wherein the adsorbing disc is rotatable, so that continuous regeneration can be effected.

7. A plant according to any preceding claim, wherein a plurality of adsorbing units are connected in series.

8. A plant according to claim 7, wherein a second adsorbing unit is provided, having an adsorbing sector included in the regeneration circuit of a first adsorbing unit and a regeneration sector included in a further regeneration circuit.

9. A plant according to claim 7 or 8, wherein each regeneration circuit comprises a heater on the input side of the adsorbing disc and cooling means on the output side.

10. A plant according to claim 9, wherein a heat pump is connected between the heaters and the cooling means respectively.

11. A plant according to any of claims 7 to 10, wherein a heat pump is connected between the inlet and the outlet for the regeneration gas.

12. A plant according to any of claims 7 to 11, wherein, after its regeneration treatment, the regeneration gas is introduced into the purified process gas stream.

13. A plant according to any of claims 7 to 12, wherein the regeneration circuit includes a branch duct through which at least part of the regenerated and cooled regeneration gas can be passed through a cooling sector of the adsorbing disc.

14. A plant according to claim 13, wherein the regeneration gas leaving the cooling sector can be introduced into the purified process gas.

15. A plant according to any of claims 7 to 14, wherein the regeneration gas can be passed through the respective adsorbing unit in the opposite flow direction to that of the process gas.

16. A plant according to any preceding claim, wherein both the process gas and the regeneration gas are drawn through.

17. A plant according to any preceding claim, wherein both the process gas and the regeneration gas are forced through.

18. A plant according to any preceding claim, wherein the process gas and the regeneration gas comprise air.

19. A plant according to any of claims 1 to 17, wherein the regeneration gas comprises an inert gas.

20. A plant according to claim 1, substantially as described with reference to the accompanying drawings.

21. A method for the recovery of solvents, using a plant as defined in any preceding claim, wherein at least a part of the regenerated and cooled regeneration gas is branched off from the regeneration circuit and is passed through a cooling sector of the adsorbing disc.

22. A method according to claim 21, wherein the regeneration gas leaving the cooling sector is introduced into the purified process gas.

23. A method according to claim 21 or 22, wherein the regeneration gas is passed through the respective adsorbing unit in the opposite flow direction to that of the process gas.

24. A method according to any of claims 21 to 23, wherein both the process gas and the regeneration gas are drawn through.

25. A method according to any of claims 21 to 23, wherein both the process gas and the regeneration gas are forced through.

26. A method according to any of claims 21 to 25, wherein the process gas and the regeneration gas comprise air.

27. A method according to any of claims 21 to 25, wherein the regeneration gas comprises an inert gas.

28. A method for the recovery of solvents, substantially as described with reference to the accompanying drawings.

29. A solvent, for instance a hydrocarbon or a halo-hydrocarbon, when obtained by operation of a plant according to any of claims 1 to 20.

30. A solvent, for instance a hydrocarbon or a halo-hydrocarbon, when obtained by a method according to any of claims 21 to 28.

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